

# Earth Independent Medical Operations

A preview of what's to come

2/2023

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- **ExMC EIMO TIM Participants – June 2022**
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  - Augustine, Philip
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  - Johansen, Ben
  - Kreykes, Amy
- **Additional ongoing work**
  - Submission of manuscript for publication in IEEE – ongoing
  - January, 2023 ExMC/Operations Leadership TIM on EIMO
- **Images are from;**
  - NASA public domain
  - ExMC presentations and publications (2020 and 2022)
  - Paramount's Star Trek The Original Series\*
  - Paramount's Star Trek the Next Generation\*
  - Disney's Star Wars\*
  - Columbia's Passengers\*
  - Fox's Firefly\*
  - Amazon's The Expanse\*

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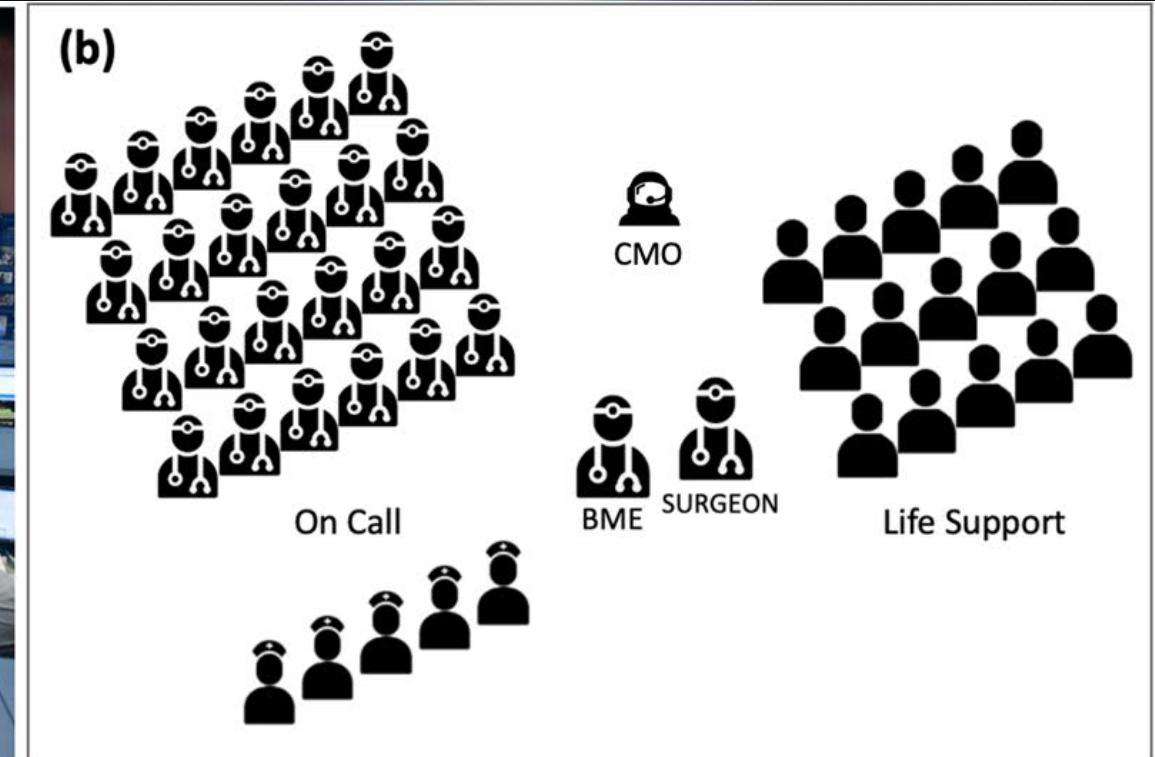
## What Is EIMO?

**EIMO is the transition of medical primacy from terrestrial to space-based assets to enable support of astronaut health and performance.**

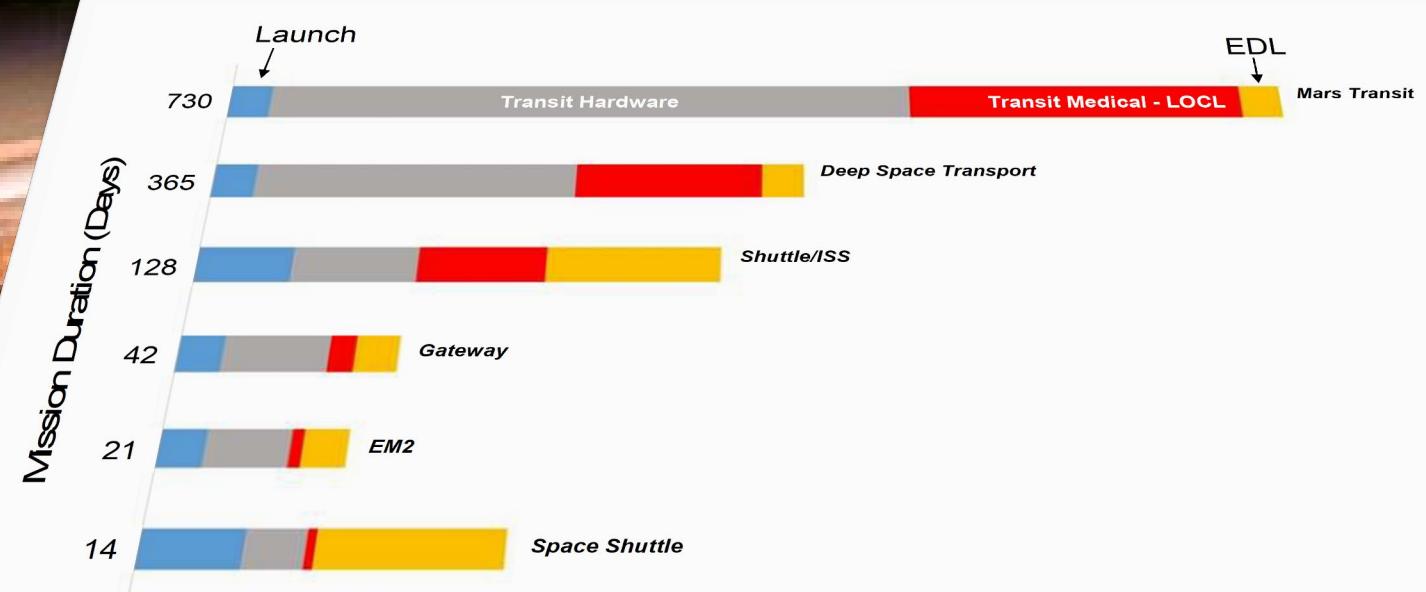
**This will be a process enabling progressively resilient deep space exploration systems and crews to reduce risk and increase mission success.**

**Terrestrial assets will continue to provide pre mission screening, planning, maintenance, and prevention while on board care, response to unexpected medical events, management of communication delays, and communication dropouts will increasingly be required of the crew.**

# Why Change?



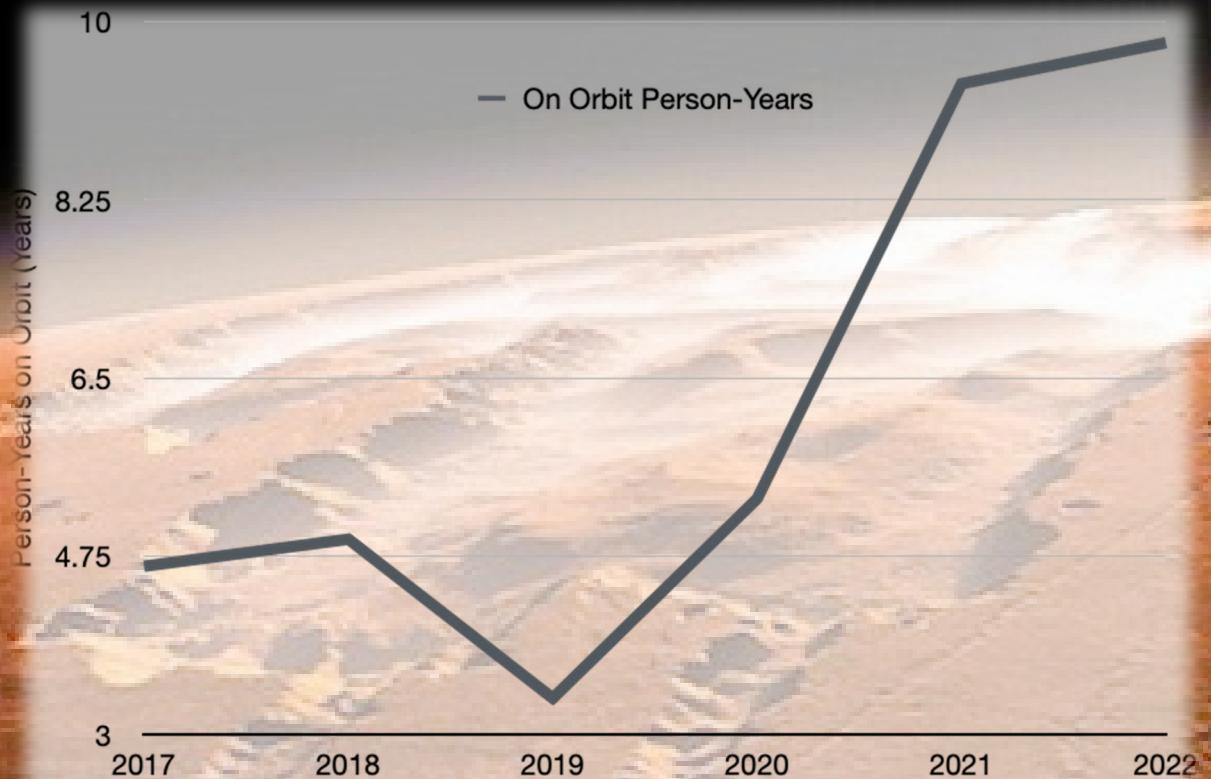
# Why Change?



Mission Risk (LOC)

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# Why Change?



# So Where Do We Start?



# Imagineering

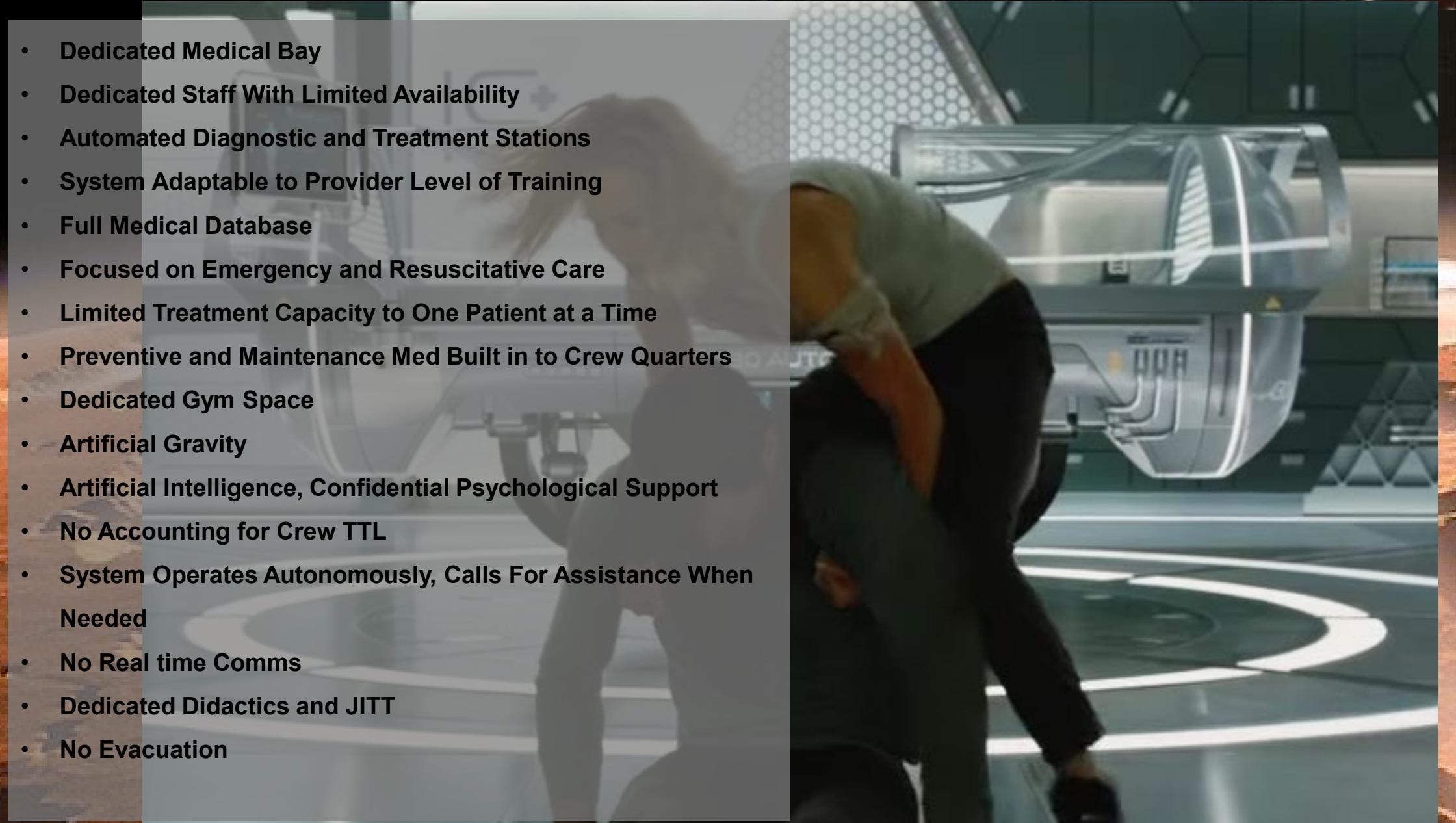
- Dedicated Medical Bay w/ MCI Capability
- Dedicated Medical Staff, Specialists Off Ship.
- Specialized Physician Training: Prevention, Medicine and Surgery
- Scheduled Check ups
- Artificial Gravity, Dedicated Gym Space
- On Site Medical Mission Risk Assessment
- Resupply Only Upon Mission Completion
- Limited Evacuation
- Computer Diagnostic and Treatment Assistants
- Full Medical Database on Board
- Limited Telemedical capability Often not Real Time
- Research Built in to Work Detail
- Self Contained Labs and Imaging
- Multi Use Tools
- Passive Medical Monitoring
- Physician Support for Planetary Excursions
- Dedicated Ship's Counselor
- Inpatient, Emergency, Surgical, and Critical Care Stations



- Limited First Aid Capabilities on Most Ships
- Dedicated “Hospital Ships” Travelling with Large Fleets
- Space Stations Have Small Dedicated Medical Bays
- Small Ships Must Evacuate Injured Crew
- No Dedicated Medical Staff on Small Ships
- First Aid Training with Computer Assistance
- Computer Assisted Diagnosis and Treatment (Droids)
- Dedicated Medical Staff
- Reusable Tools
- Limited Non Local Communication
- Generalized Trauma Stabilization and Recovery Tanks
- Regenerative Medicine
- Prosthetics
- No Psychiatric Care
- Self Contained Labs and Imaging on Large Vessels
- Plug in Monitoring Stations
- Accounts for Crew TTL



- Dedicated Medical Bay
- Dedicated Staff With Limited Availability
- Automated Diagnostic and Treatment Stations
- System Adaptable to Provider Level of Training
- Full Medical Database
- Focused on Emergency and Resuscitative Care
- Limited Treatment Capacity to One Patient at a Time
- Preventive and Maintenance Med Built in to Crew Quarters
- Dedicated Gym Space
- Artificial Gravity
- Artificial Intelligence, Confidential Psychological Support
- No Accounting for Crew TTL
- System Operates Autonomously, Calls For Assistance When Needed
- No Real time Comms
- Dedicated Didactics and JITT
- No Evacuation

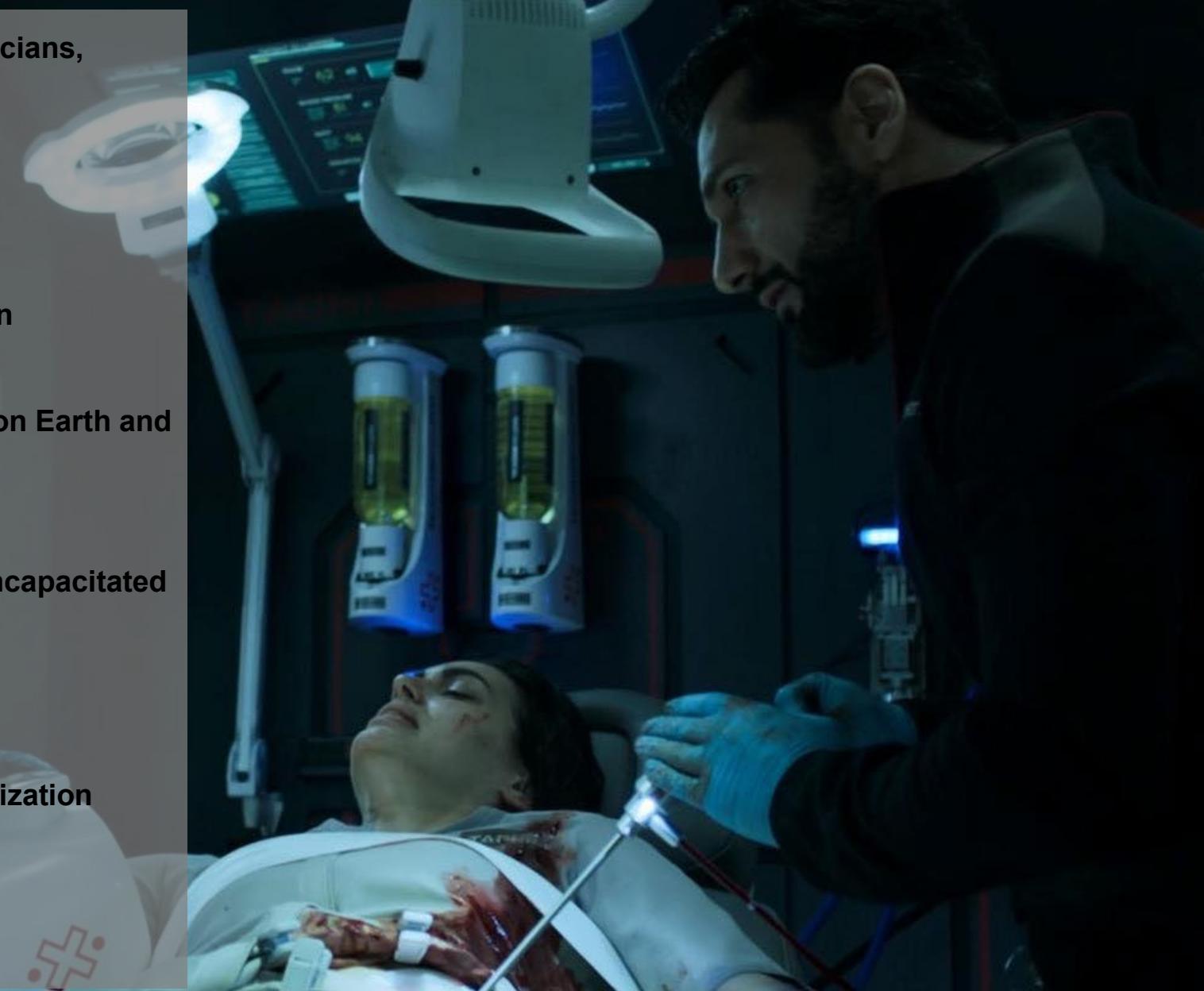


- Dedicated Medical Bay On mid Sized Ships, Single Patient
- Dedicated Medical Staff vs. Designated “medic”
- No Real Time Comms
- Resupply Only Upon Mission Completion
- Full Hospitals Only on “Core Worlds”
- Limited Higher Medical Capability on Large Ships and Some Colony Worlds
- No Computer Assistant or Database
- No Telemed
- Limited Surgical Capability on Board
- Evacuation is Mission Duration
- Multi Use Tools
- Limited Medical Monitoring
- No Dedicated Psychological Support, But Physician can “Sedate” Aggressive Patients
- Artificial Gravity
- Nutrition Supplements
- Regular Exercise Built in to Crew Schedules



# A Few Imagineering Examples

- Designated Medics on Long Haul Ships, Not Physicians, Perform Other Crew Functions As Well
- Dedicated Medical Bay with Multiple Beds
- Accounts for TTL
- Plug in Monitor
- Limited Medical Supplies with Resupply At Mission Conclusion
- Stations Have More Robust Care with Specialists on Earth and Mars
- Computer Based Diagnostics and Treatment
- Adapts to Provider Training Level as Backup for Incapacitated CMO
- JITT
- Partial Databases Available On Board
- Limited Surgical Capability, Largely Medical Stabilization
- No Artificial Gravity
- Dedicated Gym Space with Scheduled Exercise
- Medications to Prevent Deconditioning



- **What are the challenges associated with EIMO?**
- **What concepts/structures are necessary to answer these challenges?**
- **What does “medical system” mean/what are its’ components (hardware, software, supplies, education, etc...)?**
- **Who are the experts and stakeholders needed to build these systems?**

**Table 2: NASA Standard 3001 Revision 1A Level of Care 5 Definition**

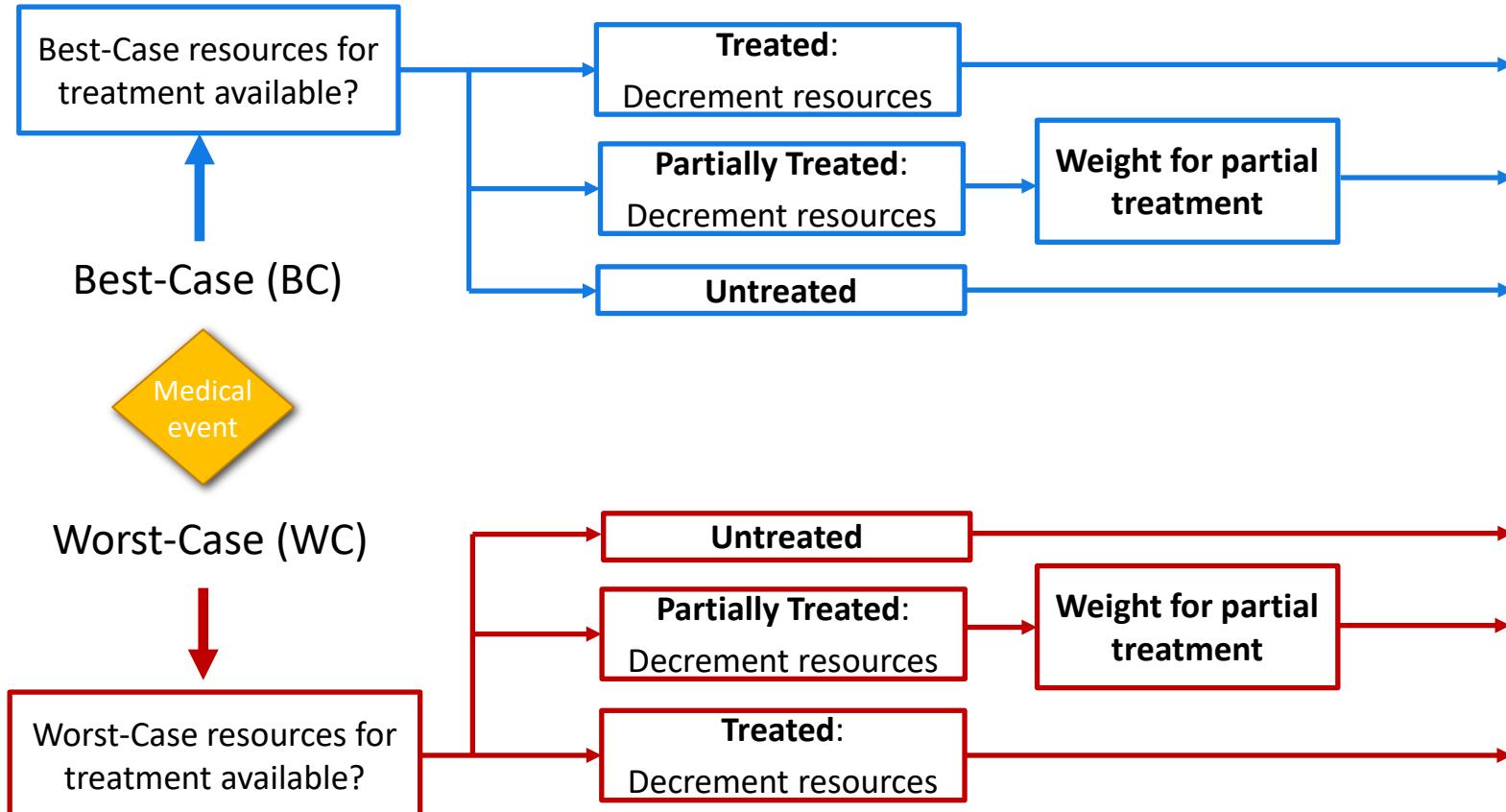
#### **4.1.6 Level of Care Five**

*A high level of potential risk exists that personnel may experience medical problems on orbit at some time during the mission.*

- 4.1.6.1** Preventive strategies shall be used to a greater degree to reduce the overall risk. The ability to support chronic illness is limited.
- 4.1.6.2** Intervention strategies shall be used to reduce the risk to an acceptable level, including increasing levels of autonomous advanced care in the form of medications, equipment, training, or consumables over and above those for previous levels.
- 4.1.6.3** The training and skill of the caregiver shall be at the physician level, because of the exclusively autonomous nature of the mission.
- 4.1.6.4** The scope of medical care available shall be limited or triaged because of availability of supplies, consumables, or mission risk.  
*Return to Earth is not a viable option for more serious illness/injuries. Impact to overall mission is greater.*
- 4.1.6.5** Level of Care Five shall be provided for lunar/planetary missions greater than 210 days.

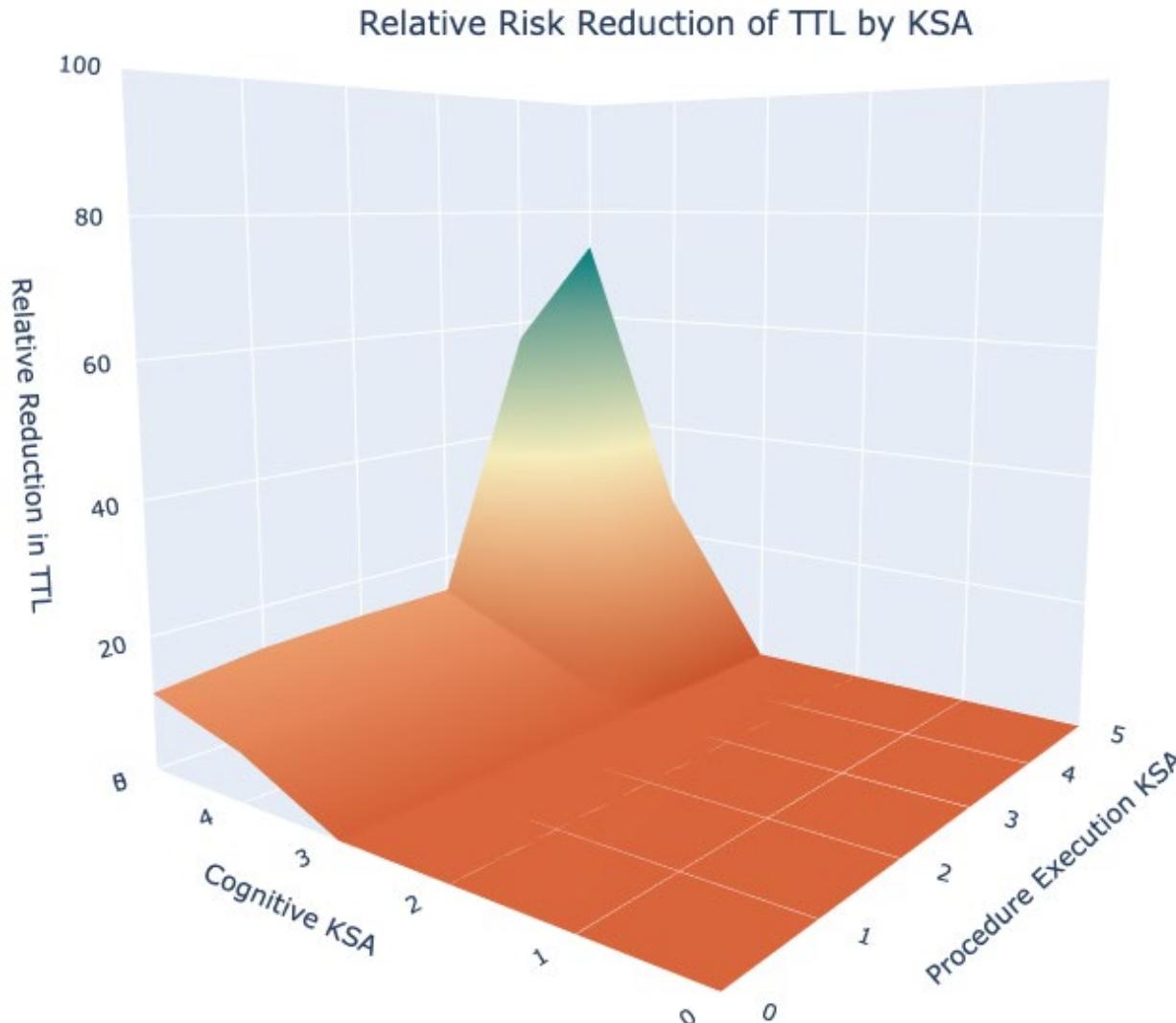
#### **4.1.7 Termination of Care**

NASA shall have a policy and procedures for termination of care.



## Calculate:

- Clinical Phase duration
- Task Impairment for each clinical phase
- End States
  - LOCL
  - RTDC
  - TTL – a function of TI and CP

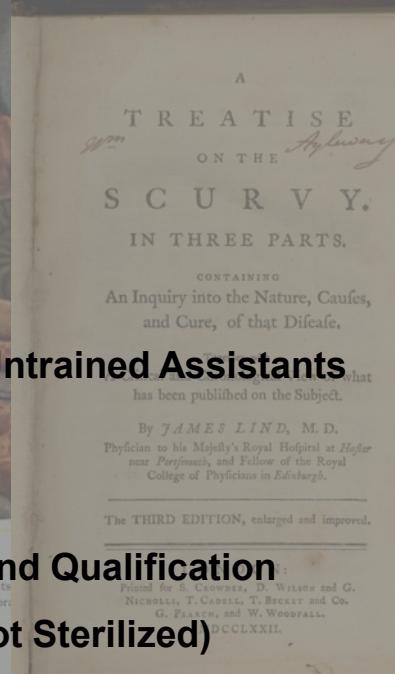
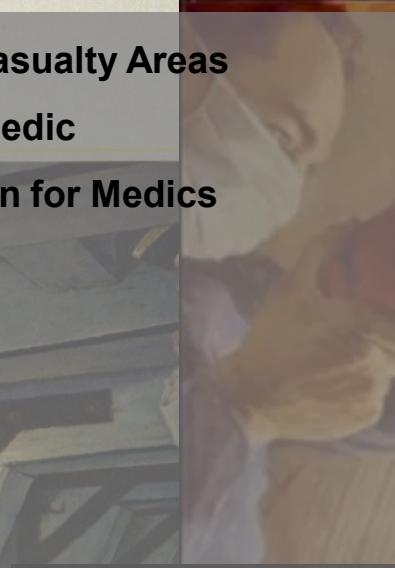


		Percent of Task Time Lost Mitigated by KSA					
		Procedure Execution KSA					
Cognitive KSA	0	0%	0%	0%	0%	0%	0%
	1	0%	0%	0%	0%	0%	0%
	2	0%	0%	0%	0%	0%	0%
	3	0%	0%	0%	0%	0%	0%
	4	7%	8%	8%	8%	26%	26%
	5	12%	13%	14%	14%	57%	73%

\*The Evidence Library data set has not yet been reviewed therefore these results are preliminary

# Real world Example: Clinical

- No Dedicated Medical Bay, Designated Casualty Areas
- Full Physician On Board or Designated Medic
  - Specialized Course with Certification for Medics
- Both Surgical and Medical Training
- Research Built in Early on
- No Real Time Comms
- “Database” on Board, with “JITT”
- No Computer Assistant
- Nutrition Supplementation
- Limited Psychological Support
- Empiric or Experienced Based Kit
- Limited Evacuation Capability
- Resupply Only on Mission Completion
- Improvised Care with Limited Supplies/ Untrained Assistants
- Quarantine of Whole Ship
- Exercise Part of Crew Rotation
- Limited to Extensive Pre trip Screening and Qualification
- On Board Disinfection For Tool Reuse (not Sterilized)



# Engineering the Future

DAY 1: Tuesday, June 15 <sup>th</sup>	TIME
Intro	8:30 AM – 8:45 AM CST
<b>Present DRMs (25 Min Discussion, 5 Min Present)</b>	
Provide DRM1 (High Volume Commercial Space) to Groups	8:45 AM – 8:50 AM CST
DRM 1 Breakout Discussion (25 MIN)	8:50 AM – 9:15 AM CST
Provide DRM 2 (Long Duration Lunar Station) to Groups	9:15 AM – 9:20 AM CST
DRM 2 Breakout Discussion (25 MIN)	9:20 AM – 9:45 AM CST
Provide DRM3 (Mars Mission) to Groups	9:45 AM – 9:50 AM CST
DRM 3 Breakout Discussion (25 MIN)	9:50 AM – 10:15 AM CST
Breakout Presentation: DRM 1 ( Commercial Space) (15 Min = 5 MIN per 3 Groups)	10:15 AM – 10:30 AM CST
Discuss Extended Lunar Base (45 Min)	10:30 AM – 11:15 AM CST
<b>Synthesis of Group Ideas &amp; Break (15 MIN)</b>	11:15 AM – 11:30 AM CST
Breakout Presentation: DRM 2 (Lunar Base) - 5 MIN/group	11:30 AM CST – 11:45 AM CST
Discuss Commercial spaceflight 3-30 day (45 MIN)	11:45 AM – 12:30 PM CST
<b>Lunch (1 HOUR)</b>	12:30 PM – 1:30 PM CST
Return and Breakout Presentation: DRM 3 (Mars Mission) - 5 MIN/group	1:30 PM CST – 1:45 PM CST
Discuss Mars Mission (45 MIN)	1:45 PM – 2:30 PM CST
<b>Synthesis of Group Ideas &amp; Break (15 MIN)</b>	2:30 PM – 2:45 PM CST
Discussion to Clean up, Synthesize Ideas, and Add Final Thoughts	2:45 PM – 3:30 PM CST
Review Agenda – Day 2 Preparation	3:30 PM – 4:00 PM CST

## What Is EIMO?

**EIMO is the transition of medical primacy from terrestrial to space-based assets to enable support of astronaut health and performance.**

**This will be a process enabling progressively resilient deep space exploration systems and crews to reduce risk and increase mission success.**

**Terrestrial assets will continue to provide pre mission screening, planning, maintenance, and prevention while on board care, response to unexpected medical events, management of communication delays, and communication dropouts will increasingly be required of the crew.**

- 1) Pre-Mission Planning*
- 2) Acute and Emergent Management Decision Making*
- 3) Prolonged Decision Making*
- 4) Supplies and Resource Management*
- 5) Task Load Management*

- **Important Domains of EIMO Pre Mission Planning**
- 1) Define the anticipated activities
- 2) Identify the relevant, treatable conditions
- 3) Define mission relevant outcomes
- 4) Collect data to support PRA
- 5) Set acceptable risk tolerance level
- 6) Run PRA
- 7) Adapt PRA output for specific mission operations
- 8) Set system requirements
- 9) Coordinate with engineers to ensure requirements are fulfilled
- 10) Determine the required onboard Knowledge, Skills, and Abilities (KSA)
- 11) Determine required skills for each crew member
- 12) Train crew members to necessary level of knowledge, skill, and ability (KSA)
- 13) Design appropriate onboard routine training/practice modules
- 14) Design on board Just-In-Time Training (JITT)
- 15) Establish mission support schedules
- 16) Establish mission support protocols and flight rules

# Engineering the Future

